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Lubrication

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This Issue

KEEP HYDRAULIC OILS CLEAN

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LUBRICATION

A TECHNICAL PUBLICATION DEVOTED TO THE SELECTION AND USE OF LUBRICANTS

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KEEP HYDRAULIC OILS CLEAN

In order to obtain the longest possible service from a hydraulic oil, it is essential that the oil be kept clean and free from contaminants. This applies not only to the time that the oil is in actual service, but also during storage and installation.

This is the second in a series of two articles relating to industrial hydraulics. The first, which appeared in the July issue, dealt primarily with the requirements, properties, and characteristics of the fluid, as well as the factors that should govern its selection. The current article is concerned with ways and means of keeping the oils and systems clean.

STORAGE AND HANDLING

Refiners and marketers of hydraulic oils are particularly careful to assure that the oil is absolutely clean when it is delivered to the customer. The customer should likewise exercise equal care to assure that the oil is just as clean when it is installed in the hydraulic system. Contamination of the oil by such materials as dust, water and lint can be prevented easily by observing a few simple precautions:

Store drums on their sides—indoors if possible, but in any event under a shelter of some sort.

Before opening a drum, clean the top so that no dirt can fall in the oil.

Any containers or hoses used in transferring the oil from the drum to the equipment reservoir should be thoroughly clean.

The oil should be filtered as it enters the reservoir. If the fill pipe on the reservoir does not contain a filter screen, a funnel equipped with a 200 mesh screen will be satisfactory.

These rules are simply common sense and should be second nature to anyone handling hydraulic oils; yet the amount of trouble that develops because they are not observed is surprisingly large.

IN SERVICE

Hydraulic system manufacturers exert every effort to design their systems to minimize the possibility of contamination. However, despite all precautions, contamination will occur and the extent will vary with the type of system, its condition and the nature of its application. Cutting oils or coolants containing fine metallic particles may leak into the system. Greases can gain an entry through packing glands or piston rods. Atmospheric dust can enter through the reservoir breather. Surface paints, rust proof preparations, gasket cements and pipe sealing compounds may be suspended in the oil.

Contaminants can be classified broadly as:

1. Extraneous materials such as dirt, rust, and scale, which are not attributable to the oil.

Courtesy of Fram Corporation

Figure 1 — Cut-away view of cellulose pack filter with replaceable cartridge.

2. Soluble or insoluble products of oil deterioration resulting from oxidation or polymerization reactions.

Although contaminants of either classification can adversely affect the operation of a hydraulic system and therefore should be removed, the oil itself, in the case of contamination by extraneous materials, will probably be suitable for continued service. Consequently it is simply a matter of economics as to whether it is cheaper to discard the contaminated oil or remove the contaminants from the oil so it may be re-used. When contamination is due to oil deterioration, the hydraulic oil should be replaced.

There are various basic methods, both continuous and batch, that can be employed to remove contaminants and purify oil. The equipment user must decide which is most practical and economical in each case. With a batch method, the oil must be removed from the hydraulic system for treatment. This necessitates the use of another charge of oil if the equipment is to operate during the interim. With continuous methods, the purification or reconditioning equipment is an integral part of the hydraulic system and the oil does not have to be removed from service. Another disadvantage of a batch method is that the contaminants are allowed to circulate and build up in the hydraulic system until the oil is removed for treatment.

Gravity Settling

A relatively simple means of removing a major portion of any material suspended in a hydraulic oil involves transferring the oil to a settling tank and permitting it to remain undisturbed for a period of time during which the contaminants will separate by gravity. Any water present will also settle out unless it has formed a stable emulsion with the oil.

Horizontal tanks with V-shaped or sloping bottoms serve as the most effective settling tanks. Although separation of contaminants will occur at room temperature, the process can be hastened by heating the oil and maintaining it at a temperature of 120-160°F. To accomplish this, the settling tank should have either jacketed walls or hot water coils. Care should be taken to prevent the oil from being overheated or appreciable oxidation might take place. It will be observed that practically no settling will occur while the oil is being heated due to the convection currents created. Settling times may vary, but it is recommended that the oil be allowed to remain in the tank for at least ten days.

Centrifuging

Centrifuging will achieve the same results as gravity settling but is much faster, since the separating force is several thousand times that of gravity. As with settling, centrifuging will remove foreign impurities, insoluble oxidized material, dirt and water, but will not separate liquids that are mutually soluble in the oil, or impurities of the same gravity as the oil.

Water may be added to the oil to be centrifuged. This will aid in the removal of impurities which have gravities of the same order as that of the oil and also any soluble acidic materials which may be more soluble in water than in oil. Care should be observed in applying wet centrifuging to inhibited oils, as certain types of additives may concentrate at the oil-water interface and a portion of them will be removed. Dry centrifuging will not remove additives.

Continuous Reconditioning

Purification equipment integrated with the hydraulic system for continuous reconditioning of the oil provides filtration for the removal of insoluble and some soluble contaminants and heat for vaporizing moisture. The location of filters in any hydraulic system depends on many factors, and the manufacturer should be consulted as to the most satisfactory arrangement. It is customary for the filters to be located at some point in the system after the pump. In some instances the filtering equipment may be so installed that the full pump discharge passes through the filter. In other installations only a portion of the oil passes through the filter, the balance being by-passed. This arrange-

ment is becoming increasingly popular because should the filter become plugged, operation of the hydraulic system is not impaired and there is no danger of the filter being back-washed. In some instances, a separate pump may be installed to circulate oil from the reservoir through the filter and back to the reservoir.

Three basic types of filters are available, characterized by the nature of the filtering medium employed. When the elements become partially clogged with contaminants, they can either be cleaned or replaced.

Metallic or *mechanical filters* contain closely woven metal or discs of metal as the filtering elements. They will remove coarse, solid contaminants but not soluble oxidized material, water, or finely divided contaminants such as dust and some insoluble oxidation products. These filters can be used safely with inhibited oils, as they will not remove additives.

Absorbent (inactive) filters contain materials such as cotton waste, wood pulp, wool yarn, felt, flannel, cloth, paper, mineral wool, quartz, diatomaceous earth and asbestos as filtering elements. Not only do these materials remove coarse contaminants but they will also take out fine particles, water, and water soluble impurities. They will not remove soluble oxidation products nor additives from inhibited oils.

Adsorbent (active) type filters remove impurities and contaminants by chemical attraction in addition to purely mechanical means. Boneblack, charcoal, chemically-treated paper, Fuller's earth and other active-type clays are examples of materials used as filtering elements. In addition to both coarse and fine insoluble particles, these filters can remove practically all insoluble sludge, water and soluble oxidized materials. *Furthermore, they may remove most additives used in inhibited hydraulic oils,* and consequently considerable care should be exercised in their application.

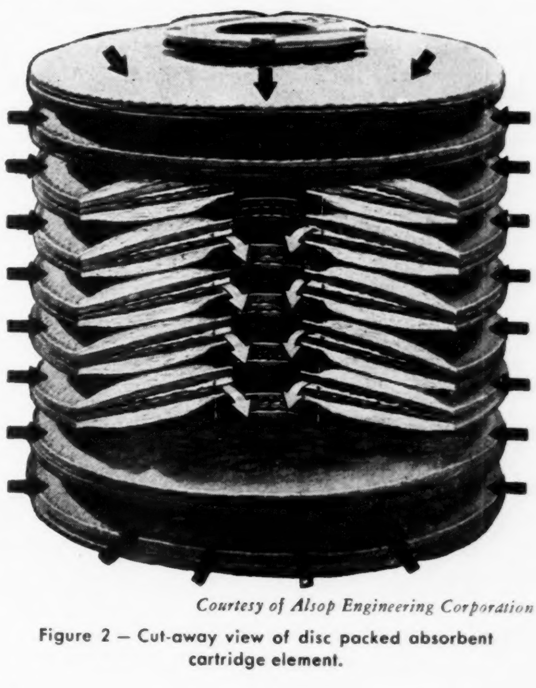
DRAIN SCHEDULES

By using the reconditioning methods just described, the service life of an oil can be extended appreciably. However, it must be understood that the treatments do not transform a used oil into a new one; they are simply means of assuring that the longest life possible can be realized from a given oil. Eventually, after prolonged use, the condition and nature of the oil will have changed to such an extent that it is no longer suitable for safe and efficient operation. When this stage is reached, it is essential that the oil be replaced with a new charge. Before installation, the entire system should be examined and, if necessary, cleaned in accordance with procedures to be described.

The frequency with which used oil should be drained and replaced depends on the nature of the oil and the operating conditions to which it is subjected. Consequently, it is impossible to establish a drain schedule that will apply categorically to all systems. Visual inspection of the oil to note any change in appearance, such as darkening or thickening, may serve as a rough guide to indicate that the need for a change is imminent. However, periodic testing of the oil is the safest and best way. The oil supplier should be consulted with reference to establishing the intervals at which the oil should be tested, as the frequency of testing will not be a fixed period but will increase as the condition of the oil starts to change appreciably. If laboratory facilities are not available, the oil supplier will usually arrange to have the oil tested at his own laboratory. The oil should be changed when characteristics such as viscosity and acidic properties begin to increase at an accelerated rate. If the oil is drained at the proper time, the hydraulic system should be in such condition that subsequent cleaning will be relatively easy. On the other hand, if the oil is allowed to continue in service after it should have been replaced, cleaning and flushing of the system may be time consuming and laborious.

CLEANING AND FLUSHING OF HYDRAULIC SYSTEMS

Satisfactory performance of hydraulic systems depends on the use of clean oil in clean equipment. The importance of having the systems absolutely clean before introducing a charge of oil cannot be emphasized too strongly.



Courtesy of Alsop Engineering Corporation

Figure 2 — Cut-away view of disc packed absorbent cartridge element.

TROUBLE SH

PUMP MAKING NOISE

Possible Causes	*Remedy*
1. Partially clogged intake line, intake filter or restricted intake pipe.	1. Clean out intake, strainer or eliminate restriction. Be sure suction line is completely open.
2. Air leaks	2. See below.
(a) At pump intake piping joints.	(a) Test by pouring oil on joints while listening for change in sound of operation. Tighten as required.
(b) At pump shaft packing (if present).	(b) Pour oil around shaft while listening for change in sound of operation. Follow manufacturers' recommendations when changing packing.
(c) Air drawn in through inlet pipe opening.	(c) Check to be certain suction and return lines are well below oil level in reservoir. Add oil to reservoir if necessary.
3. Air bubbles in intake oil.	3. Use hydraulic oil containing a foam depressant.
4. Reservoir air vent plugged.	4. Air must be allowed to breath in the reservoir. Clean or replace breather.
5. Pump running too fast.	5. Check recommended maximum speeds from manufacturers' descriptive bulletins.
6. Too high oil viscosity.	6. Use lower viscosity oil. Follow manufacturers' recommendations for given temperature and service.
7. Filter too small.	7. Capacity may be adequate only when just cleaned, and should have added capacity.
8. Rag, paper, etc., pulled into suction line or pump.	8. Remove.
9. Coupling misalignment.	9. Re-align.
10. Pump head too loose, or a faulty head gasket.	10. Test by pouring oil over head, replacing gasket or tighten head as is necessary.
11. Stuck pump vane (vane type pump).	11. Inspect for wedged chips or sticky oil, and re-assemble.
12. Worn or broken parts.	12. Replace.

NO PRESSURE IN THE SYSTEM

Possible Causes	*Remedy*
1. Pump not delivering oil for any of the above reasons.	1. Follow remedies given above.
2. Relief valve not functioning properly.	2. See below
(a) Valve setting not high enough.	(a) Increase pressure setting of valves.
(b) Valve leaking.	(b) Check seat for score mark and reseat.
(c) Spring in relief valve broken.	(c) Replace spring and readjust valve.
3. Vane or vanes stuck in rotor slots (vane type pumps only).	3. Inspect for wedged chips or sticky oil.
4. Head too loose (very infrequent).	4. Must not be tightened too tightly. See manufacturers' instructions before tightening.
5. Free re-circulation of oil to tank being allowed through system.	5. Directional valve may be in open-center neutral, or other return line open unintentionally.
6. Internal leakage in control valves or cylinders.	6. To determine location progressively, block off various parts of circuit. When trouble is located, repair.

BREAKAGE OF PARTS INSIDE PUMP HOUSING

Possible Causes	*Remedy*
1. Excessive pressure above maximum pump rating.	1. Check relief or regulator valve maximum setting.
2. Seizure due to lack of oil.	2. Check reservoir level, oil filter and possibility of restriction in suction line more often.
3. Solid matter being wedged in pump.	3. Install filter on suction line.
4. Excessive tightening of head screws.	4. Follow pump manufacturers' recommendations.

EXTERNAL OIL LEAKAGE AROUND PUMP

Possible Causes	*Remedy*
1. Shaft packing worn.	1. Replace.
2. Head of oil on suction pipe connection.	2. Sometimes necessary, but will usually cause slight leakage. Keep all joints tight.
3. Damaged head packing.	3. Replace.

LE SHOOTING

FAILURE OF PUMP TO DELIVER FLUID

Possible Causes	*Remedy*
1. Low fluid level in reservoir.	1. Add recommended oil, and check level on both sides of tank baffle to be certain pump suction line is submerged.
2. Oil intake pipe or suction filter plugged.	2. Clean filter or otherwise remove obstruction.
3. Air leak in suction line, preventing priming or causing noise and irregular action of control circuit.	3. Repair leaks.
4. Pump shaft turning too slowly to prime itself (vane type pumps only).	4. Check minimum speed recommendations in manufacturers' descriptive literature.
5. Oil viscosity too heavy to pick up prime.	5. Use lighter viscosity oil. Follow manufacturers' recommendations for given temperature and service.
6. Wrong direction of shaft rotation.	6. Must be reversed immediately to prevent seizure and breakage of parts due to lack of oil.
7. Broken pump shaft or parts broken inside pump. Shear pin or shear linkage broken.	7. Refer to manufacturers' literature for replacement instructions.
8. Dirt in pump.	8. Dismantle and clean.
9. On variable delivery pumps the stroke is not right.	9. Check pump manufacturers' instructions.

EXCESSIVE WEAR

Possible Causes	*Remedy*
1. Abrasive matter in the hydraulic oil being circulated through the pump.	1. Install adequate filter or replace oil more often.
2. Viscosity of oil too low at working conditions.	2. Check pump manufacturers' recommendations or consult your lubrication engineer.
3. Sustained high pressure above maximum pump rating.	3. Check relief or regulator valve maximum setting.
4. Drive misalignment or tight belt drive.	4. Check and correct.
5. Air recirculation causing chatter in system.	5. Remove air from system.

HEATING CAUSED BY POWER UNIT (RESERVOIR, PUMP, RELIEF VALVE AND COOLERS)

Possible Causes	*Remedy*
1. Relief valve set at a higher pressure than necessary, excess oil dissipated through increased slippage in various parts, or through relief valve or through throttle valve.	1. Reset relief valve to slightly above maximum pressure required for work stroke. Check manufacturers' recommendations for maximum pressure settings.
2. Internal oil leakage due to wear.	2. Repair or replace pump.
3. Viscosity of oil too high.	3. Follow manufacturers' recommendations for correct viscosity grade to be used at various temperatures.
4. Pumps assembled after overhaul may be assembled too tightly. This reduces clearances and increases rubbing friction.	4. Follow manufacturers' instructions when re-assembling.
5. Leaking check valves or relief valves in pump.	5. Repair.
6. Improper functioning of oil cooler or coolant is cut off.	6. Inspect cooler and see that it is working properly.
7. Automatic unloading control inoperative.	7. Repair valve.

HEATING BECAUSE OF CONDITIONS IN SYSTEM

Possible Causes	*Remedy*
1. Restricted lines.	1. If lines are crimped, replace; if partially plugged for any reason, remove obstruction.
2. Large pump deliveries not unloaded properly.	2. Make certain that open-center valves are neutralized, and that any pressure-relieving valves are in the correct position. Only small pump volumes should be allowed to remain at high pressures when clamping or running idle for long periods of time.
3. Insufficient radiation.	3. Use artificial cooling.
4. Internal leaks.	4. Locate leaks then replace packing.
5. Reservoir too small to provide adequate cooling.	5. Replace with larger reservoir, or install cooler.
6. Undersize valves or piping.	6. Check flow velocity through lines and valves and compare with manufacturers' recommendations. If excessive, replace by installing larger equipment.

COMPARISON OF PURIFICATION, FILTRATION AND RECLAMATION METHODS

	GRAVITY PURIFICATION			FILTRATION		
	Gravity Settling	*Centrifuging*		*Mechanical Filters*	*Absorption Filters*	*Adsorption Filters*
		Dry	*Wet*	*Inactive*	*Inactive*	*Active*
Filtering Media	...	...	...	Woven metal or metal discs, such as edge-type, copper ribbon, steel wool, screen or strainer types.	Cotton waste, wood pulp, wool yarn, felt, flannel, cloth, paper, mineral wool, quartz, diatomaceous earth, asbestos, etc.	Fuller's earth, bone black, charcoal and various active clays, chemically treated paper and waste.
Application to Systems						
Full-Flow	No	No	No	Yes	Not generally	Not generally
By-Pass	No	Yes	Yes	Yes	Yes	Yes
Batch	Yes	Yes	Yes	Yes	Yes	Yes
Contaminants Removed						
Insoluble Solids						
Large particle size	Yes	Yes	Yes	Yes	Yes	Yes
Small particle size	No	Some (1)	Most	No	Yes	Yes
Insoluble Oxidation Products						
Agglomerated	Some	Most	Yes	Some (2)	Yes	Yes
Dispersed	No	No	Some	No	Some	Yes
Soluble Oxidation Products	No	No	No	No	No	Most (3)
Water and Water Soluble Materials	Yes	Yes	Yes	No	Some	Some
Removal of Oil Additives	No	No	Some (4)	No	No	Some (5)

(1) Providing gravity heavier than oil. (2) Depending upon size of agglomerates. (3) Depending upon type of media.
(4) Only those which are water sensitive. (5) Depending upon type of additive.

New Hydraulic Systems

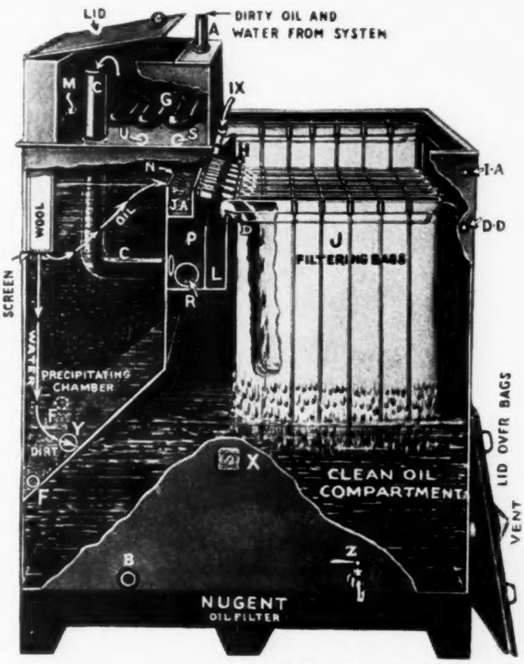
Often the hydraulic system is an integral part of new equipment and is completely sealed at the time of shipment. Manufacturers of such equipment take great care to see that no contaminants enter the system. In addition, they invariably are tested at the factory with a suitable oil containing a rust inhibitor, which insures rust protection during shipment. Therefore, in such cases it is not usually necessary to flush out the system upon receipt, for the machine is ready for the initial charge of hydraulic oil. (To be sure, check this point with your machine supplier.)

Manufacturers who, because of the size of their equipment, must ship machines in parts always cap or flange off exposed ends of hydraulic pipes. These should not be removed until assembly is made and great care must be exercised to see that no contaminants enter the exposed ends during assembly. Examination of such systems will show if they should be flushed out before initially charging the hydraulic oil.

Manufacturers who construct hydraulic systems exercise precautions to see that all mill scale, rust and other foreign matter are removed from pipes and other parts. In addition, all core sands from castings, and bending sand must be removed. This is accomplished normally by immersing the parts in dilute sulfuric acid, a process called "pickling." After removal, the acid remaining is neutralized, often by dipping in a 5 per cent soda-ash solution. Next the parts must be washed in water and dried by blowing with steam or air. Sand blasting is also used to remove rust and scale. After fabrication (bending, welding, and flanging) the interior of all piping is wire brushed to remove any materials introduced after cleaning, then blown out with air to remove the loosened material. In cases where sand cannot be removed by the above procedure, an alternative is to use hydrofluoric acid which is subsequently neutralized and washed out. After fabrication and cleaning, all interior surfaces are then rustproofed in some manner, usually with a rust inhibited hydraulic oil or a petrolatum type rustproofing compound. If the latter is used, this material must be removed before the initial charge of hydraulic oil is made. Since the compounds used are normally oil soluble, they can be removed by flushing, as outlined below. In any case, the manufacturer should be consulted to determine the best method of removing these compounds. After rustproofing, all openings are capped or flanged so that no dirt will enter.

Dirty Hydraulic Systems

If deposits tend to accumulate in a hydraulic system, they are chiefly oil oxidation products which gradually become insoluble in the oil, together with



Courtesy of Wm. W. Nugent & Co., Inc.

Figure 3 — Gravity filter with automatic dirty filter alarm, automatic water separator and ventilator.

contaminants, such as dust or lint, mineral matter from the metal parts of the system and condensation which binds the insoluble material into a sludge-like emulsion. The nature and amount of deposit present in a particular system may vary widely. Inspection may show any condition between a viscous oil film and a hard solid deposit which completely chokes oil passages.

Deposits in a hydraulic system are of two general types. If they are oily in nature and present as films or light emulsion coatings on metal surfaces, the system can be cleaned by flushing with a suitable flushing oil. In systems containing appreciable amounts of solid or semi-solid deposits (a condition which rarely, if ever, exists with modern inhibited hydraulic oils) flushing will not remove the accumulation under ordinary circumstances. In such cases the only alternative is to dismantle the system and clean it manually.

Lightly Sludged Systems

Deposits oily in nature and present as films or light emulsion type coatings on metal surfaces normally can be removed by flushing.

A suitable flushing oil should have the following properties:

1. A viscosity sufficiently high to adequately lubricate moving parts and to insure continued suspension of particles during circulation, yet low enough to have high solvent power. Usually an oil with a viscosity within the range of 70 to 110 sec-

onds viscosity Saybolt Universal at 100°F. is considered satisfactory.

2. Suitable solvent power to remove oily material (in addition to petrolatum type rustproof compounds, etc., from new system). Generally naphthene base oils are more satisfactory than paraffin base oils because of their higher solvency. It is not felt that so-called "gum or varnish solvents" are necessary in flushing oils.

3. Rust inhibitors which coat all metal surfaces with a film capable of preventing rust formation.

4. Oxidation inhibitors which permit the portion of the flushing oil trapped in the systems to blend with the final charge of inhibited hydraulic oil without adversely affecting the latter's potential service life.

The advice of the oil supplier again should be sought regarding the selection of a suitable flushing oil. Usually he will be able to furnish a product which has been prepared especially for this purpose and which will provide maximum cleaning efficiency.

Known solvents and chemical cleaners on the market today are not recommended for use in hydraulic systems for several good reasons. Among these is the fact that some do not offer sufficient lubricating value with the result that moving parts, and particularly the pump, are damaged. A second reason is that it is very difficult to remove all traces of the solvent or cleaner from the system. Just a trace of some of the commercial chlorinated solvents may be sufficient to reduce the oxidation resistance of premium grade inhibited hydraulic oils to the level of that of a straight mineral oil. Also, in the presence of a small amount of water, some of these solvents will become very corrosive to steel and copper.

Following is a suggested procedure for flushing hydraulic systems:

Drain the hydraulic oil from the system and clean the filters and strainers. It is also advisable to remove as much sludge as possible from the reservoir.

Charge the system with the recommended flushing oil and operate the equipment. During the circulation a portion of the oil should be by-passed continually through a filter and the rate of deposit removal closely observed. It is important that the valves be so manipulated that the flushing oil goes through all lines.

The time necessary to clean the system will vary, depending on the condition of the equipment. Usually from 4 to 48 hours is sufficient for most systems.

After the flushing oil has been drained from the system, the equipment should be inspected to see that it is in satisfactory condition to receive a new charge of hydraulic oil. If deposits still persist, the system will have to be reflushed or dismantled and cleaned manually.

If the flushing oil can be drained completely from the equipment, the system can then be charged with the new hydraulic oil. If appreciable quantities of flushing oil remain after draining, this should be flushed out with the hydraulic oil to be employed. This hydraulic oil can then be retained for similar application on other systems or used as a general machine lubricant after it has been suitably filtered.

Heavily Sludged Systems

When appreciable amounts of solid or semi-solid deposits are present in a hydraulic system, flushing will not remove the accumulation under ordinary circumstances. Such systems should be dismantled and cleaned mechanically.

In the mechanical removal of semi-solid or solid deposits, it is generally necessary to dismantle the system because of the inaccessibility of many parts. The method of removal depends largely on the size of the lines and other equipment, as well as the type of deposits. Scraping, wire brushing and even rotary boiler tube cleaners have been resorted to. The success of such methods will be in direct proportion to the precautions taken in seeing that all parts are suitably cleaned. As a result, it is best to have someone in charge of such operations who is experienced in this line of work.

As each part of the system is cleaned mechanically it should be blown out with air; then the freshly cleaned metal surfaces should be coated with a hydraulic oil containing a rust inhibitor. Normally the same oil finally used in the system should be used for this purpose, providing the oil is rust inhibited. Freshly cleaned metal surfaces have a tendency to rust quickly, and thus it is imperative that they be rust protected. After all parts have been cleaned, the system should be re-assembled, using care to see that no dirt, lint, pipe thread compound, etc., gets into the system.

As a final step it is advisable to flush out the system, using a flushing oil, as previously described.

SUMMARY

Cleanliness is the key to smooth, trouble-free operation of any hydraulic system. *Cleanliness* begins with the selection of the most suitable fluid, followed by its installation in *clean* equipment and continues with maintaining both the oil and the system in a *clean* condition during operation. Any effort expended in this regard will be repaid many fold by reduced maintenance costs and decreased down time.

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